OTT HydroMet

Solar Energy Insights

Discover the new Kipp & Zonen SMP12

Spectral Selectivity vs. Spectral Error: Shedding light on ISO 9060:2018

Building an effective meteorological station for solar PV

How to mitigate soiling for improved PV performance

Monitoring efficiency at Benban Solar Park – the world's fourth largest PV area

OTT HydroMet launches firmware update for the Kipp & Zonen DustIQ soiling system

How "floatovoltaics" might reshape the renewable energy landscape

A trip to the Swiss village where the world calibrates its solar monitoring instruments

Issue 03 | May 2022

Content

P3: **Discover the new Kipp & Zonen SMP12**

P4: **Spectral Selectivity vs. Spectral Error: Shedding light on ISO 9060:2018**

P6: **Building an effective meteorological station for solar PV**

P8: **How to mitigate soiling for improved PV performance**

P10: **Monitoring efficiency at Benban Solar Park – the world's fourth largest PV area**

P12: **OTT HydroMet launches firmware update for the Kipp & Zonen DustIQ soiling system**

P13: **How "floatovoltaics" might reshape the renewable energy landscape**

P14: **A trip to the Swiss village where the world calibrates its solar monitoring instruments**

Contact

If you have an application including one of our products or want to share your experiences with OTT HydroMet applications and contribute to our Insights' next issues, please email the team: experts@otthydromet.com

May 2022 | OTT HydroMet

Welcome to Solar Energy Insights

Dear reader,
Whether in your hands or on your screen, you are reading the third issue of the Solar Energy Insights by OTT HydroMet. We are a leading developer and manufacturer of environmental monitoring solutions including hydrology, meteorology, and solar energy.

Around the world, the demand for renewable energy is growing. Photovoltaics play a key role in this trend. To monitor the performance of PV plants, accurate, reliable, and easy-to-integrate measurement solutions are key.

In this edition of the Solar Energy Insights, we would like to share some stories of inspiring projects, important technical knowledge, and present our latest innovation – the Kipp & Zonen SMP12, industry's first Spectrally Flat Class A pyranometer that provides integrated heating without moving parts.

Enjoy reading!

Further Reading - Click and Learn
OTT HydroMet Blog – Observing the elements is key to better understanding our planet. This blog tells the manifold stories of experts working in environmental monitoring with help of our sensors and solutions.

OTT CAST – Environmental monitoring combines earth sciences with technology and the possibilities of big data. Ranging from hydrology to meteorology and climate studies to solar monitoring for PV plants, there is a lot to discuss, a lot to learn -
Let's Talk About the Weather!

Webinar Library – Sharing knowledge has never been so easy as today. But finding the information you look for might be a challenge. In our Webinar Library, we share a selection of useful webinars that include topics as Solar PV Monitoring, Soiling Mitigation, Bifacial PV, Rooftop Monitoring, and many more.

Discover the new SMP12 Class A pyranometer

The first manufacturer of pyranometers, Kipp & Zonen, a product brand of OTT HydroMet, introduces another innovation to solar monitoring. The new ISO- and IEC-compliant SMP12 is the industry's first Class A pyranometer that delivers integrated heating with zero moving parts* (solid-state technology) and best-in-class surge protection.

OTT HydroMet's scientists and engineers focused on making the new instrument fully compliant with the highest class of ISO 9060:2018 (see article on page 4) and created a "spectrally flat, fast response pyranometer of Class A". Its integrated heating based on solid-state technology makes the SMP12 compliant with IEC 61724-1:2021 Class A, too, while reducing maintenance needs and failure risks.

Enhanced surge protection
Enhanced surge protection helps plant operators to mitigate the impact of poor grounding, finicky power sources, and lightning on their monitoring system. The SMP12 is designed to reduce failure risks, prevent expensive on-site replacements, and maintain performance with a rock-solid leading mean time between failure (MTBF) of 10+ years.

Quartz diffusor replaces second glass dome
The SMP12 comes with a single glass dome that is heated to prevent morning dew and frost from interfering with the measurement accuracy. Its quartz diffusor acts as a second dome while enabling excellent directional response.

Fast response of less than 0.5 seconds
Including the quartz diffusor instead of a second glass dome brings further benefits. In combination with the miniature thermopile, the diffusor allows a very fast response time of less than 0.5 seconds. This allows the SMP12 to carry the label "fast response pyranometer" in addition to Class A according to ISO 9060:2018.

Furthermore, the use of the diffusor reduces the sensitivity of the instrument for thermal zero offsets and enables internal heating without moving parts and without huge offsets.

Compatible with all of OTT HydroMet's solar monitoring portfolio
To make installation as simple as possible, OTT HydroMet equipped the Kipp & Zonen SMP12 with industry-standard RS-485 connectivity and the Modbus® protocol that allows for easy integration with all data loggers and SCADA systems as well as every device of OTT HydroMet's solar monitoring portfolio.
An additional feature is the tilt angle sensor to monitor tilt angle installation down to ±0.5°. Over the months and years, installation angles can slightly vary resulting in drifting measurements. Knowing the exact tilt angle helps to improve the long-term reliability of data.

Find more information on www.kippzonen.com.

**Patents pending*

Spectral Selectivity vs. Spectral Error: Shedding light on ISO 9060:2018

By Clive Lee, Technical Sales & Services Consultant

In late 2018, the ISO 9060 standard for solar radiometers underwent a remarkable update that brought significant changes on the classification of solar radiation measurement quality. At first glance, ISO 9060:2018 appears to be mainly a renaming of radiometer classification launched in the original version from 1990. But, as often, the devil is in the details and still causing a lot of confusion within the solar industry.

ISO 9060 is titled 'Solar energy – Specification and classification of instruments for measuring hemispherical solar and direct solar radiation'. It defines what a pyranometer is for measuring global horizontal or global tilted irradiance (GHI and GTI) and, when shaded, diffuse horizontal irradiance (DHI). It also defines what is a pyrheliometer for measuring direct normal irradiance (DNI).

More than a renaming
There are several changes in pyranometer specifications between ISO 9060:1990 and the latest update ISO 9060:2018. The 2018 version states that the newly introduced Class A is 'roughly corresponding' to 1990 Secondary Standard, Class B to First Class and Class C to Second Class.

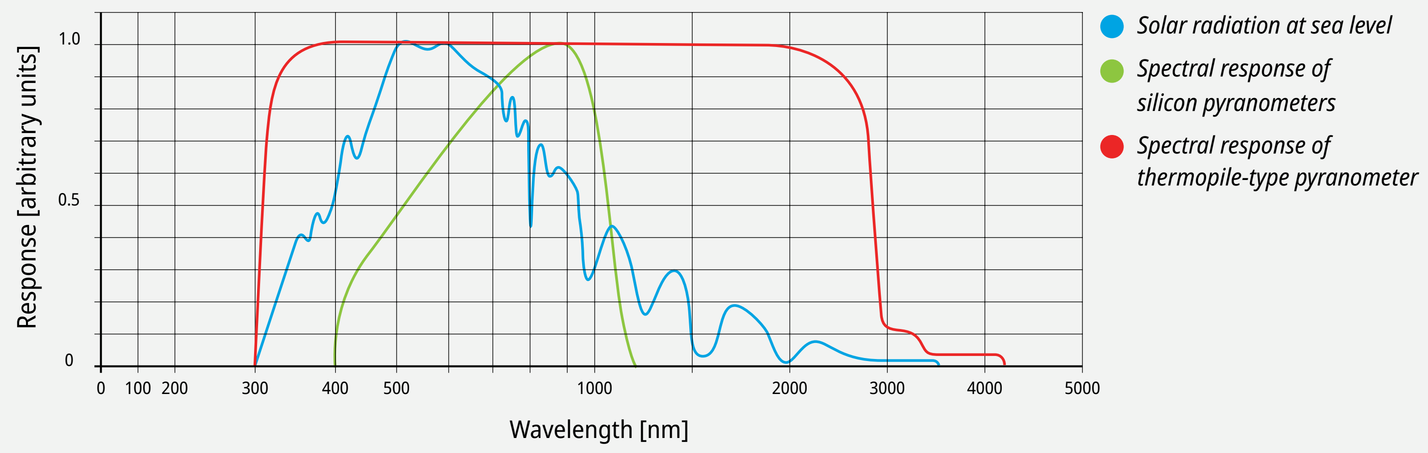
'Roughly' is the correct term; the performance parameters and testing requirements differ between 1990 and 2018.

The most difficult aspect to understand the changes between 1990 and 2018 versions of the ISO 9060 standard is the issue of spectral response/error/sensitivity/selectivity.

Broadly speaking, the 2018 update introduced a new parameter to characterize the spectral properties of a radiometer and how it reacts on different parts of light, more precisely photons with different wavelengths. Different to the Spectral Selectivity from the 1990 version, the Spectral Error considers the important fact that the composition of sunlight, the spectrum, varies depending on the time of day in a way more relevant for the application of solar measurements. That said, the new 2018 version reflects the actual wavelength range of sunlight much better than its predecessor.

A new class for basic radiometers
Additionally, by introducing the new Class C on the entry level, the standard now covers well-built photodiode radiometers, too, that have not been covered in the old version. Those photoelectric sensors, including silicon cells and photodiodes, have a limited and uneven spectral response that does not meet the spectral selectivity specifications for a pyranometer (or pyrheliometer) as defined by ISO 9060:1990; and thus, had to be described as a 'Silicon Pyranometer', or similar terminology.

The graphs below show a typical clear sky solar radiation spectrum at sea level and the response of an entry-level glass-dome thermopile pyranometer, such as the Kipp & Zonen CMP3 and SMP3 models. Also, for a typical silicon photodiode sensor, like the Kipp & Zonen SP Lite2 and RT1. The spectra are normalized to the peak/maximum being 100% for easy comparison.



The spectral selectivity is a function of the spectral absorptance of the black coating and the spectral transmittance of the dome/window and/or diffuser material and of any optical filters that are fitted.

Kipp & Zonen Pyranometer ISO 9060 Classifications
Kipp & Zonen CMP series and SMP series pyranometers, and the CM4 high temperature pyranometer meet the appropriate classification limits for spectral error and have a spectral selectivity of <3%. Thanks to that, they all meet the ISO 9060:2018 Spectrally Flat criteria.

		Spectrally Flat	**Spectrally Flat**	**Spectrally Flat**
ISO 9060:2018	Class C	Class C	Class B	Class A
ISO 9060:1990	Not allowed	Second Class	First Class	Secondary Standard
Performance	Lower	→	→	Higher
Passive pyranometers	SP Lite2 (Fast Response)	CM4 CMP3	CMP6	CMP10 CMP11 CMP21 CMP22
Smart pyranometers	RT1	SMP3	SMP6	SMP10 SMP11 SMP12 **(new)** SMP21 SMP22

Note: ISO 9060:2018 Class A pyranometers must be individually tested to ensure that their temperature and directional responses meet the requirements of the standard.

For a more detailed explanation of ISO 9060:2018 and the changes it brought compared to 1990, check the long version of this article with the same title on our blog:
https://blog.otthydromet.com/

Building an effective meteorological station for solar PV

Weather conditions have a huge influence on photovoltaic output. Even intermittent cloud cover can have a dramatic effect on incident solar energy, while other factors like air temperature, wind direction and speed, precipitation, humidity and air pressure can all influence the efficiency of solar cells. Monitoring weather conditions accurately is crucial in order to understand variations in PV plant performance.

Why monitor weather parameters?

While variations in weather conditions may be of only passing concern to the average domestic PV user, they are of critical importance for commercial and industrial PV systems.
For large installations, even small relative fluctuations in performance can make a huge difference to overall productivity, and any source of output variation must be closely monitored to ensure the overall system is performing optimally. In these cases, meteorological monitoring is essential in order to determine whether variations in output are due to weather conditions, or indicative of more serious hardware degradation or malfunction.

Weather monitoring is, therefore, an essential part of understanding PV system health and scheduling maintenance on time. Analysis of historical data – on precipitation and wind conditions, for example – enables seasonal trends to be uncovered, which can in turn be used to optimize cleaning and maintenance schedules on a seasonal basis.
Which weather parameters are important for solar PV?

Solar irradiance

Measurements of solar irradiance are crucial in order to determine the efficiency of a solar plant. This is usually expressed in terms of a **performance radio (PR)**: the actual yield of the plant (how much energy it produces in a given time period) expressed as a percentage of its theoretical yield (how much energy it *could* produce in that time period assuming the panels convert the incident light into energy at their nominal efficiency).

The theoretical yield of a plant can only be calculated using measurements of different components of solar irradiation. This means that these measurements are essential in order to calculate the performance ratio.

$$\text{Performance Ratio} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Performance ratio is a vital indicator for PV asset owners – but it's far from the only parameter of interest. Monitoring other weather parameters that directly impact solar cells is essential to obtain a complete picture of plant performance.

Ambient air and module temperatures

Photovoltaic efficiency is strongly dependent on temperature.[1] As a rule of thumb, for every degree centigrade the temperature rises over 25 °C, the efficiency of a typical PV module drops by around 0.5%. Measuring both the temperature of ambient air and the modules themselves enables the calculation of a temperature-corrected performance ratio, giving PV plant operators a more accurate picture of plant performance.

Wind speed and direction

Wind can also have a dramatic effect on PV module temperature. Since PV surface temperatures are hotter than ambient air, wind cools them down, thus increasing their efficiency and output in warmer environments. Wind also has a significant effect on soiling, so knowledge of wind conditions can play an important role in soiling monitoring.[2]

Since high wind speeds can damage PV installations, monitoring wind speed and direction is often important for determining safe locations for equipment – and can affect insurance payments.

Precipitation

Different kinds of precipitation can have a range of effects, both good and bad, on PV plants.
While heavy rainfall can dramatically reduce soiling by washing off dirt, light rainfall can actually *increase* panel soiling.[3] Meanwhile, hailstorms can cause serious damage to panels and equipment.[4]

Humidity, air pressure and dew point

Air pressure, humidity and dew point affect the occurrence of snow, frost and condensation on panels which, as well as decreasing energy output, can have an effect on soiling. Air humidity, in particular, can also produce spectral changes which affect the productivity of PV modules.

Building an Effective Meteorological Station for Solar PV

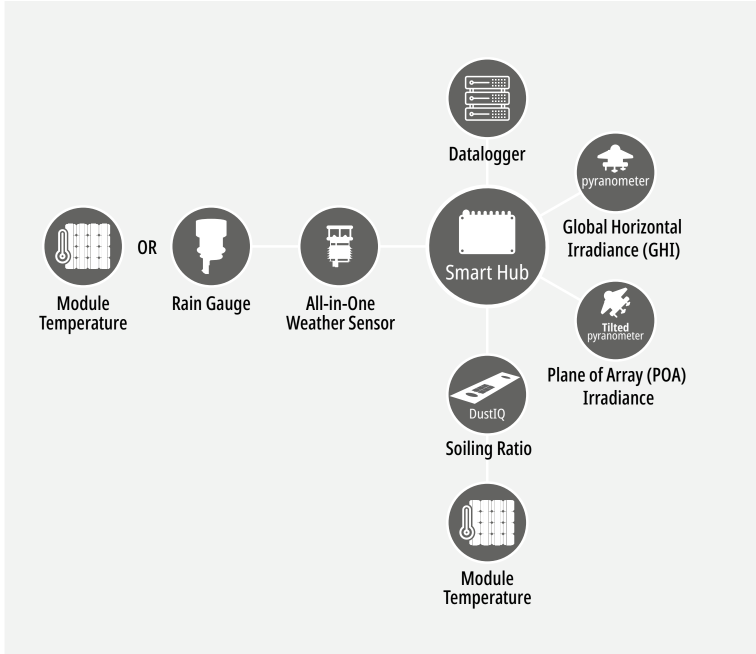
Thanks to the number of parameters of interest and the sheer volume of different sensors on the market, assembling a meteorological station capable of providing complete and accurate information can be daunting.

Often, mixing-and-matching sensors from different vendors means contending with multiple data formats and software interfaces as well as having to grapple with complex mounting configurations and long cable runs. OTT HydroMet offers a complete range of meteorological sensing solutions that provide a simplified and integrated experience.

Meteorological Sensors from OTT HydroMet

OTT HydroMet meteorological sensors are tailor-made for commercial and industrial solar PV installations.
The Lufft WS line offers powerful instruments with various combinations of sensors for measuring atmospheric parameters. For solar PV applications, we recommend the Lufft WS600. It measures air temperature, wind speed and direction, relative humidity, air pressure, and precipitation.

Lufft WS all-in-one sensors come with active ventilation and integrated heating to deliver best-in-class accuracy and long-term reliability, providing commercial and industrial PV facilities with unparalleled insight into plant performance.
Thanks to its simple modular design the WS600 can be easily integrated into existing data acquisition systems via a single Modbus connection. Integration with other OTT HydroMet solutions is made especially easy using our Smart Hub, which enables pyranometers, soiling monitoring systems, and weather sensors to be connected.



A complete environmental monitoring system from OTT HydroMet means all relevant weather parameters can be easily, accurately, and reliably monitored with proven instruments from its brands such as Kipp & Zonen and Lufft.

Selected setup recommended for solar PV plants:

WS50PV All-in-One Weather Sensor
SMP10 Pyranometer
CVF4 Pyranometer Ventilation Unit
DustIQ Soiling Monitoring System
Smart Powered Hub

To find out more about our meteorological solutions for solar PV applications, get in touch with OTT HydroMet today.

References and Further Reading

1. Skoplaki, E. & Palyvos, J. A. On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/power correlations. *Solar Energy* **83**, 614–624 (2009).
2. Effect of soiling on wind-induced cooling of photovoltaic modules and consequences for electrical performance Request PDF: www.researchgate.net
3. Maghami, M. R. *et al.* Power loss due to soiling on solar panel: A review. *Renewable and Sustainable Energy Reviews* **59**, 1307–1316 (2016).
4. Makarskas, V. *et al.* Investigation of the influence of hail mechanical impact parameters on photovoltaic modules. *Engineering Failure Analysis* **124**, 105309 (2021).

How to mitigate soiling for improved PV performance

The DustIQ soiling monitoring system uncovers soiling-related performance losses and helps to optimize cleaning schedules.

PV soiling can significantly diminish energy generation, anywhere from several percent annually, all the way up to 50% in the worst cases. Recovering that lost generating capacity starts with monitoring the rate of soiling and then implementing cleaning strategies.

Many contributors to soiling come from above. Over time, dust from surrounding environs rise into the air and settle onto PV panels. So, too, do emissions from cars and trucks. Droppings from passing birds also end up on solar panels, along with plant pollen. Biofilms of bacteria, algae, lichen, mosses, or fungi also contribute to soiling. The makeup of soiling material varies by location, with airborne dust often the largest component.

All of these sources block sunlight from reaching the photovoltaics that turn light into electricity. Some, like bird droppings, can be mostly opaque, while others, like thin films of dust and emissions, may be more transparent but will still keep light from the active PV surface.

Unlike irradiance, the rate of soiling and output loss is not constant over an entire farm. It is very location-dependent – even within a single PV plant. Measurements from around the world show an average daily decrease in panel capacity of as much as 2%, with the buildup sometimes stable and not always due to environmental factors. Rain, for example, can impact soiling because it cleans debris off PV modules. Studies showed that significant precipitation can be great at combating soiling, but the associated recovery in power generation is temporary. Light rain, on the other hand, can actually make soiling worse by washing particles out of the air and onto a panel, as well as by providing the moisture needed to encourage biofilms to grow.

Power loss because of soiling is typically at least 3% to 4% annually, assuming a standard location and the use of optimized cleaning strategies. In contrast, the decrease in PV performance can be more than 50% in heavily polluted and desert regions with no cleaning other than rainfall.

A soiling mitigation strategy

As these findings demonstrate, proper cleaning is essential to increase the amount of light reaching PV modules and improve power generation. But cleaning costs money, both from the direct expense of cleaning processes and from any temporary reduction in output that may result while water or other cleaning liquids evaporate. Cleaning may also result in a permanent degradation of PV panel performance, depending upon the cleaning method and frequency.

One approach is to clean when the payback from the increased power output is enough to make soiling reduction worthwhile. It depends on a cost-effective and accurate soiling monitoring system that is adaptable to the local environment, as this makes it possible to optimize cleaning frequency. The right monitoring system can also assist in evaluating cleaning methods.

The Kipp & Zonen DustIQ soiling monitoring system uses photodiodes that capture reflected blue light emitted by a diode light. The LEDs pulse and shine upward on a transparent material, a window that experiences the same soiling conditions as nearby PV panels. As soiling occurs, light transmitted through the window drops and reflected light picked up by the photodiodes rises. Software translates the readings into soiling measurements.

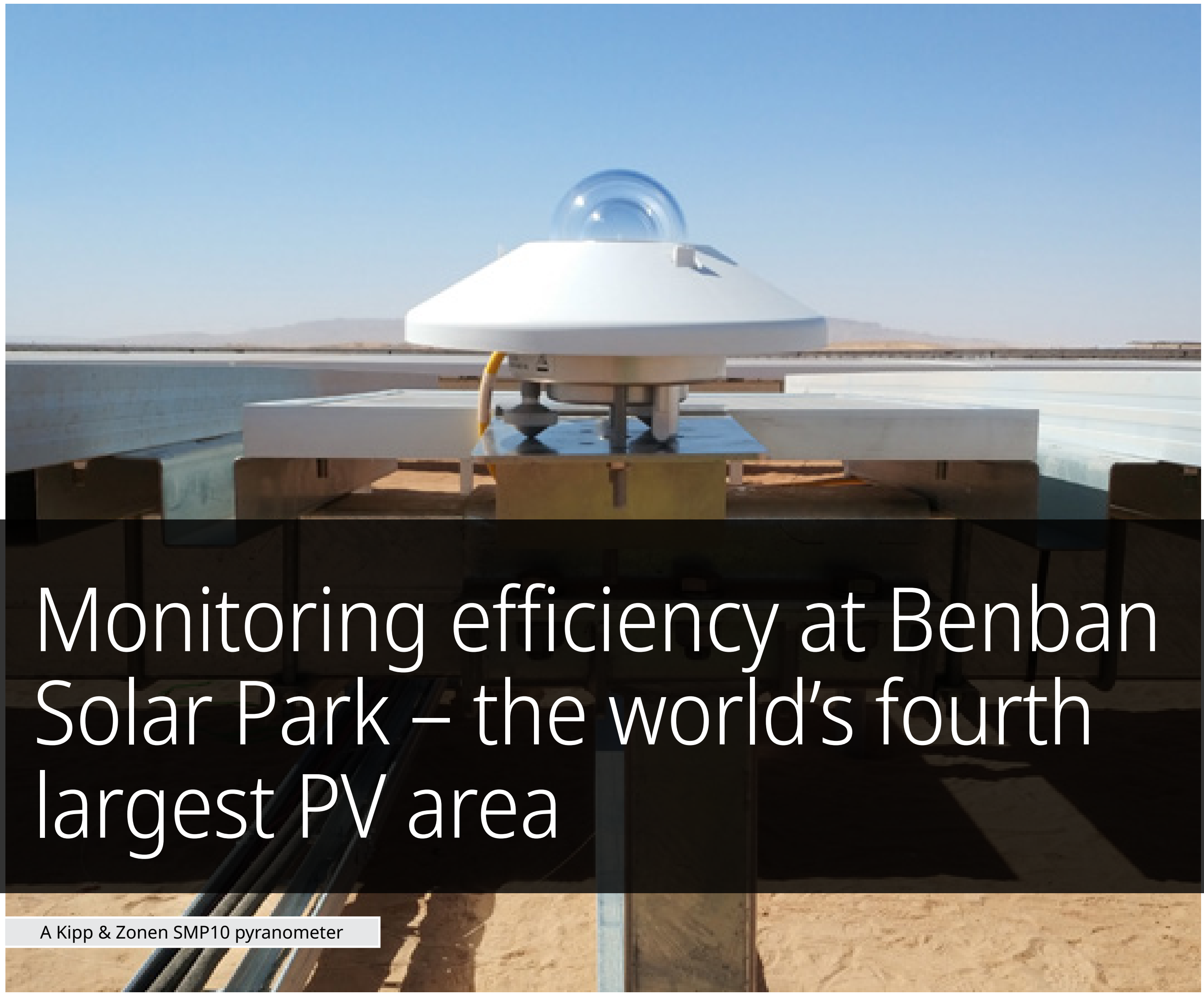
This approach doesn't depend on a clean reference surface or sunlight, meaning DustIQ can be cleaned with the rest of the solar array and can run day or night. DustIQ is also less expensive than using a clean reference PV panel. Consequently, DustIQ can be placed at many locations within an array and still be less costly than a smaller number of clean reference panels, as well as providing data from more locations, thereby improving monitoring accuracy.

The DustIQ system can be adapted to best counter the characteristics of local dust, once a local dust calibration is taken. With the new firmware update (see page 12), the calibration process got faster and simpler.

Once in place, data provided by DustIQ can help operators use solar plant monitoring software to determine when cleaning is needed, using setpoints determined by the user. These triggering values are a function of the cost of cleaning, the cost of electricity and the level of soiling and energy losses.

For example, a 1-megawatt plant with an average of five hours of sunlight per day. If the cleaning costs $250, the electricity price is 10 cents per kilowatt hour (0.1 $/kWh) and the rate of soiling is 0.2% per day, then cleaning should be done every 22 days and the monitoring system's alarm should be set to 95.6% transmission loss.

Analyzing DustIQ readings can determine the soiling rate, the only factor in the calculations that an operator may not know and may vary daily. It can also help determine which cleaning process is best among competing approaches, such as manual versus automatic. The outcome can be the successful selection and implementation of a better cleaning process.



Monitoring efficiency at Benban Solar Park – the world's fourth largest PV area

A Kipp & Zonen SMP10 pyranometer

Monitoring the output data of a PV station reveals volatilities every day. There are many reasons that lead to different output data. Identifying them and taking the right measures is an important challenge for plant operators.

To quickly identify the cause for sinking performance and to mitigate losses at the huge Benban Solar Park, Beijing Intell-Sun Technology installed environmental monitoring systems including Kipp & Zonen pyranometers, sun trackers, and soiling monitoring sensors.

The Benban Solar Park has been built amid the Nubian Desert, about 40 km north of Aswan, Egypt. It consists of various PV plants structured as long rectangles and run by different operators. The total area of will cover 37 square kilometers with a total power of 1,800 MW, making it one of the largest PV areas in the world.

The total installed capacity of the project showcased here is 186 MW, divided into three plants, each of them is about 60 MW. Building Benban Solar Park is extremely significant for Egypt, which took 90 percent of its electricity from oil and gas in early 2018. With help of this and other projects, Egypt hopes to increase domestic renewable energy production to 20% by the end of 2022 and 42% by 2035.

Typically, power output volatilities are caused by one of these four reasons:

- Intensity of solar radiation energy received by PV panels
- Technical deterioration from elements as the DC bus, inverter, etc.
- Dust and sand on PV modules blocking the sunlight
- Photoelectric conversion efficiency caused by the modules' back temperature

Plant operators cannot change the weather, and they have little impact to control the back panel temperature. What they can do is to improve the operating efficiency of the whole PV station, that is, reducing the operating loss of the power station and cleaning the panel to improve the percentage of solar radiation reaching the PV panels.

Thorough monitoring the performance ratio of a PV plant requires precise instruments for solar radiation and back panel temperature. Weather parameters bring additional insights. In order to locate a problem on the PV plants quickly, the engineers subdivided the three rectangular plants into several areas with a set of measurement instruments to represent each area, and then divided the whole plant into dozens of small areas for fine management. When the problem is found, the O&M site staff can locate the fault area accurately. It is not necessary to search the whole plant, which ensures the timeliness of solving the problem.

To ensure the data authenticity of these small regional devices, they installed two sets of more accurate measurement systems including sun trackers and weather stations in the central of each plant. The weather stations can measure atmospheric parameters as air temperature, wind speed and wind direction, and precipitation. This data serves as a benchmark to provide data support for O&M site staff to make decisions. For quick detection of problems, the frequency of data acquisition and calculation was set to 1 Hz – that is one signal per second.

In the Nubian desert, land use costs are low, but strong winds blow lots of dust and sand onto the PV panels. Soiling can significantly decrease power generation. Cleaning the panels regularly, especially after sandstorms, is mandatory. However, there is a large area of PV panel in a power station, making one-time cleaning costs relatively high. Timing of cleaning is an important issue. If the cleaning time is too frequent, the costs will explode, and if the cleaning time is missed, the plant performance shrinks.

On this plant at Benban Solar Park, the engineers tried to balance these two factors by installing the soiling monitoring system Kipp & Zonen DustIQ. They divided this station into several zones according to the prevailing wind direction and dust conditions, and installed DustIQ's in each zone to monitor dust everywhere. With help of the soiling data, the operators can calculate the threshold of the soiling ratio by analyzing the relationship between dust index and power generation. Below this threshold, the loss of power generation benefits equals the cleaning costs.

Read the whole story on our website!

A Kipp & Zonen SOLYS2 sun tracker and a weather station

Innovative soiling monitoring system:
the Kipp & Zonen DustIQ

OTT HydroMet launches firmware update for the Kipp & Zonen DustIQ soiling system

The pioneering soiling monitoring system Kipp & Zonen DustIQ is now better than ever. From now on, OTT HydroMet provides all devices with a new firmware that simplifies both handling and calibration. Active users of all versions can update to the new firmware, too.

DustIQ is an optical sensor to measure the amount of dust, sand, and other shading objects on PV panels. It is used to determine the soiling ratio, to optimize cleaning schedules, and to increase the profitability of PV installations – especially in arid and desert areas. With the new firmware update, among other advantages, the DustIQ adapts to surrounding conditions faster and enables an easier field calibration. Here is an overview:

Better response to soiling with increased sensitivity
Measurements taken outdoor in various desert regions across the world show that the DustIQ underestimated the degree of transmission loss with its earlier factory calibration dust slopes. Those various sites report that the outdoor dust slope is a factor reaching from 1.8 and 2.6 higher than the factory calibration. Based on these reports, an average factor 2 is found and implemented to the new firmware version 22000 to achieve **a better response to soiling**.
Independent research* also confirms that the DustIQ with the earlier factory calibration dust slope was underestimating transmission loss.

The shorter field calibration procedure is easier to perform and mitigates risks of possible errors. Additionally, it saves time. Also, the required soiling ratio threshold of 5% is lowered to 3%. Tests have shown that this has a minimal impact on the accuracy of the field calibration.

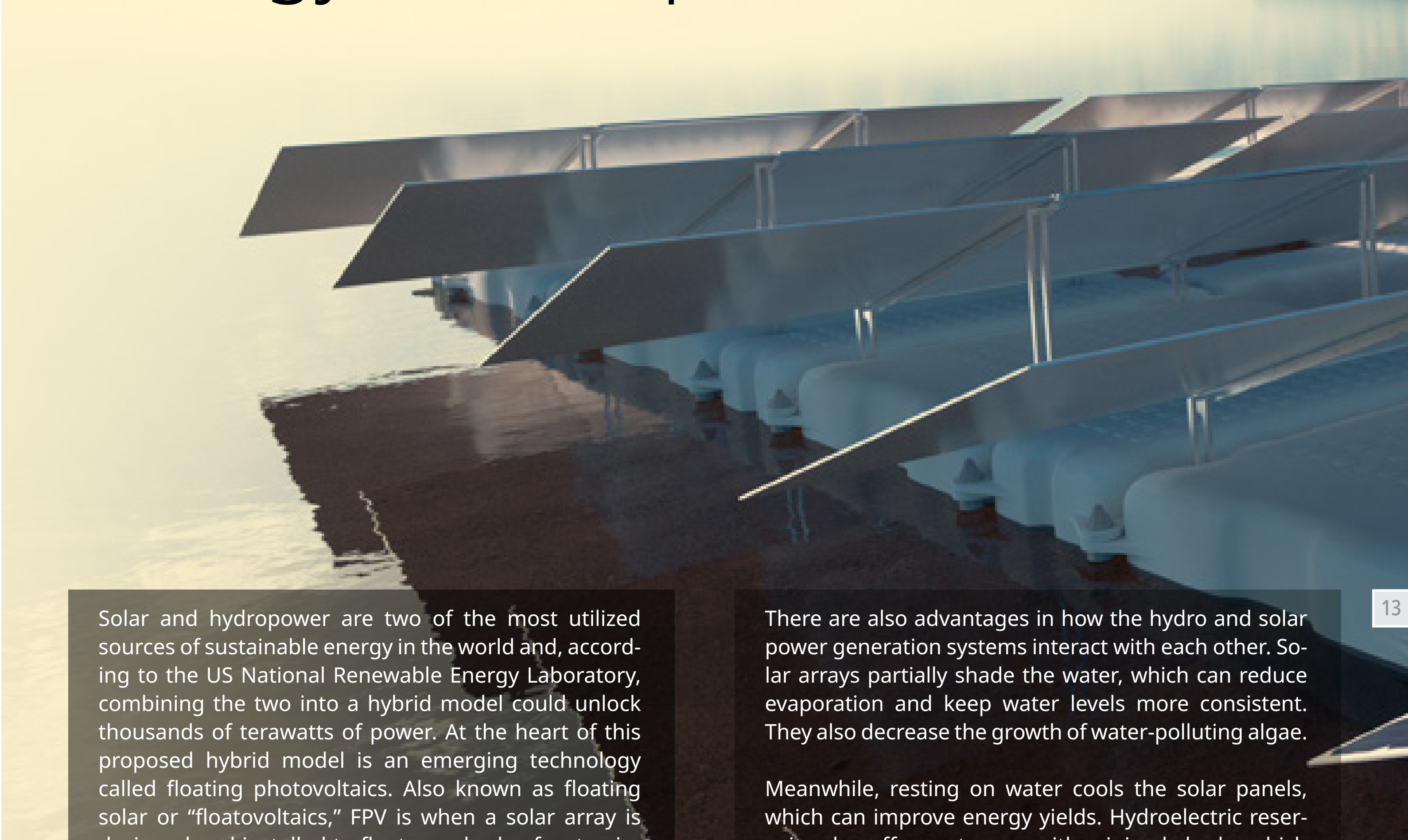
Plain communication and increased functionality
Previously, the DustIQ reported with binary bits (0000 0000 0000 0000) to inform users of potential errors. To simplify readings, errors are now being displayed with numerical codes. With the new firmware, the DustIQ uses registers 26 and 27 with signed integers for communication.

The new firmware allows customers to **tare out offsets**. This is especially useful for users who experience offset in their DustIQ. The procedure is described in the instruction sheet. Additionally, it minimizes the DustIQ's tiny temperature dependency when operating at temperatures different from the factory calibration (25 °C).

The calibration button has an **increased functionality** and can now be used to initiate one of these three actions: Reset to factory configuration, Start field calibration, Start tare function.

Find more detailed information and a link to the firmware update files on the OTT HydroMet Blog: blog.otthydromet.com.

****Soiling Sensors** – Laboratory Calibration of a Light Scattering Soiling Sensor, Dr Bing Guo*



How "floatovoltaics" might reshape the renewable energy landscape

Solar and hydropower are two of the most utilized sources of sustainable energy in the world and, according to the US National Renewable Energy Laboratory, combining the two into a hybrid model could unlock thousands of terawatts of power. At the heart of this proposed hybrid model is an emerging technology called floating photovoltaics. Also known as floating solar or "floatovoltaics," FPV is when a solar array is designed and installed to float on a body of water, instead of on land or building structures.

According to the NREL report, installing FPV systems on the world's hydropower station reservoirs could hypothetically provide 10,600 terawatt-hours of solar-only power. That figure represents nearly half of the world's energy requirements, based on estimates that in 2018 the world consumed 22,300 terawatt-hours of electricity.

Advantages of the Hydro-FPV hybrid model
The build-out of transmission lines can be one of the most cost-intensive aspects of installing any solar array. The Hydro-FPV hybrid eliminates most of that cost by sharing the transmission infrastructure already in place as part of the existing hydropower plant.

A second benefit of Hydro-FPV is that it makes two renewable energy sources that are inherently intermittent less so. They complement one another by providing energy when the second source is not and vice versa.

There are also advantages in how the hydro and solar power generation systems interact with each other. Solar arrays partially shade the water, which can reduce evaporation and keep water levels more consistent. They also decrease the growth of water-polluting algae.

Meanwhile, resting on water cools the solar panels, which can improve energy yields. Hydroelectric reservoirs also offer vast areas with minimal shade, which can help optimize solar power generation.

Hydro-FPV plants can rely on proven measurement instruments
"Floating arrays can be easily oriented towards the sun direction and follow the sun's orbit during the day to have optimal coupling," said Dr. Joop Mes, senior scientist at OTT HydroMet. Dr. Mes added that FPV needs the same sort and amount of solar irradiation and weather instruments as land-based systems.

With few competing uses for the water surface behind reservoirs, the area may come at a bargain price for solar developers, compared with neighboring land prices. This cost reduction could make the Hydro-FPV hybrid model particularly appealing in urban areas serviced by hydropower.

This article is an excerpt from a whitepaper published by OTT HydroMet and SmartBrief. You can find a link to the whole document including real world applications, information on operation and maintenance, and a forecast on the development potential of floatovoltaics on the OTT HydroMet blog.

A trip to the Swiss village where the world calibrates its solar monitoring instruments

Interview With Dr. Joop Mes, Senior Scientist at OTT HydroMet

Measuring the energy of the sun precisely is not as easy as tracking distances or weight. To set an international standard for solar monitoring instruments radiometers, the World Radiation Centre in Davos, Switzerland, holds comparison events that result in the World Radiometric Reference.

In early fall 2021, the 13th WMO International Pyrheliometer Comparisons (IPC) took place. As a manufacturer of high-quality solar monitoring systems, OTT HydroMet with its brand Kipp & Zonen is participating every time to ensure our instruments reach the highest possible accuracy and provide reliable and intercomparable data. One of the participants was Dr. Joop Mes, Senior Scientist at OTT HydroMet. In this short interview, he explains what the IPC is and why it is so important.

Joop, you went to Davos for the third time. The pictures you took there look great. But I assume it was not the great landscape that made you travel to Switzerland.
That's true. Although the Graubünden area holds fantastic treasures for hikers and climbers, our destination was the World Radiation Center in Davos, which is located at the PMOD, which stands for Physikalisch-Meteorologisches Observatorium Davos. That World Radiation Center takes care of the World Radiometric Reference (WRR) for solar radiation.

What exactly is that World Radiometric Reference and why do you need to update it every five years there?
Solar radiation is different from units like the kilogram or the meter, which are physical constants that originally were kept in a lab. Today, they are defined differently, of course, but still, they are constant. The WRR in contrast is a "consensus Standard". This means the world has agreed that the averaged reading of the World Standard Group, consisting of five absolute cavity pyrheliometers installed at PMOD, gives the true amount of solar radiation. All other solar radiation instruments have a calibration that is traceable to this WRR.

How does that International Pyrheliometer Comparison look like? Who is participating?
According to their website, the IPC is open to all WMO-affiliated or WMO-related institutions, such as national hydrometeorological services. Manufacturers of radiometric equipment as we from OTT HydroMet, calibration and research institutions, and other stakeholders can participate, too. Everyone can calibrate their absolute cavity radiometer every five years at the IPC, directly to this world standard. The outcome is a correction factor for the reading of your pyrheliometer, which is called WRR-factor. This number is usually very close to unity (=1); e. g. 0.9989 or so. As OTT HydroMet, we participated with our PMO-6 absolute cavity pyrheliometer.

Does that mean that this reference changes from event to event?
Yes, it does. The WRR comes from the World Standard Group, which is a group of measurement instruments, not an absolute standard kept in a lab. These instruments could also drift, which would mean the world standard would drift. So, part of the event's purpose is to check (using all the instruments of the participants) if the WRR has been stable.

How does our participation impact our business as a manufacturer of solar irradiance monitoring instruments?
We are not only a manufacturer but also an accredited calibration lab. Obviously, we try to calibrate as accurately as possible. Therefore, we calibrate our reference instruments using our absolute cavity pyrheliometer. We need to have a valid, recent calibration of this instrument, so we go to Davos every five years to get an updated WRR factor for our instrument.

Also, we attended the symposium (which is held during cloudy or rainy days) and participated in discussions on standards, accuracy, intercomparisons of instruments and metrology. Furthermore, we had the chance to visit the research labs and test facilities of the institute and had fruitful discussions with the Swiss radiation scientists on radiation measurements not only in the visible range but also UV and Infrared radiation.

The new SMP12 at the 13th IPC in Davos

Erik Nagel, Firmware Engineer at OTT HydroMet, is adjusting the pyrheliometer to take accurate measurements of solar radiation.

Insights for Experts

OTT HydroMet

Solutions for Hydrology, Meteorology, and Solar Energy

AQUARIUS	KIPP & ZONEN	Lufft	SUTRON	OTT	ADCON	HYDROLAB	METEOSTAR
Analytics software for real-time, accurate surface and groundwater data	Solar radiation and atmospheric properties for meteorology and solar energy	Ambient weather monitoring for meteorology and weather critical operations	Hydro-meteorology monitoring, data collection and management for water, weather, and renewable energy	Hydrology monitoring and data management for surface and groundwater	Plant disease monitoring and agricultural meteorology for smart farming and irrigation management	Environmental water quality monitoring for surface and groundwater	Software for real-time weather forecasting in aviation weather and flight planning

OTT HydroMet

www.otthydromet.com

Lufft KIPP & ZONEN

OTT HydroMet brands

www.lufft.com www.kippzonen.com